Resilient PNT using eLoran during GNSS Denial

Mr Chris Hargreaves
General Lighthouse Authorities of the United Kingdom and Ireland

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Need for resilient PNT in e-Navigation

IMO Maritime Safety Committee has stated:
"e-Navigation systems should be resilient and take into account issues of data validity, plausibility and integrity for the systems to be robust, reliable and dependable. Requirements for redundancy, particularly in relation to position fixing systems should be considered."
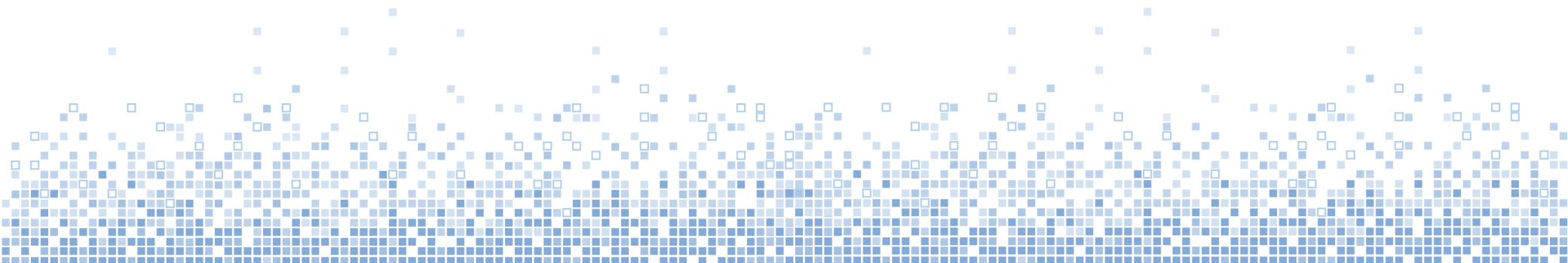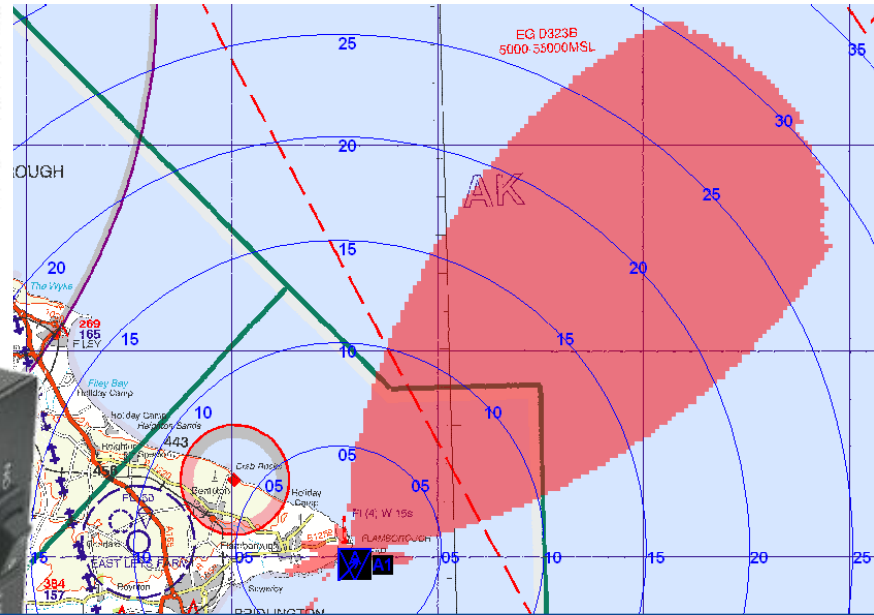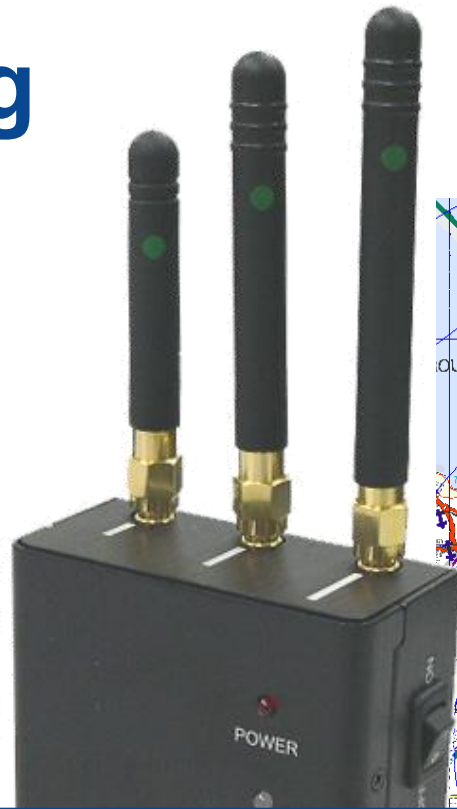
Use of GPS

- GPS feeds most shipboard equipment

- This equipment fails if GPS is lost
  - Alarms sound on Bridge
  - Loss of Navigational awareness
  - Danger to vessels and Navigators!
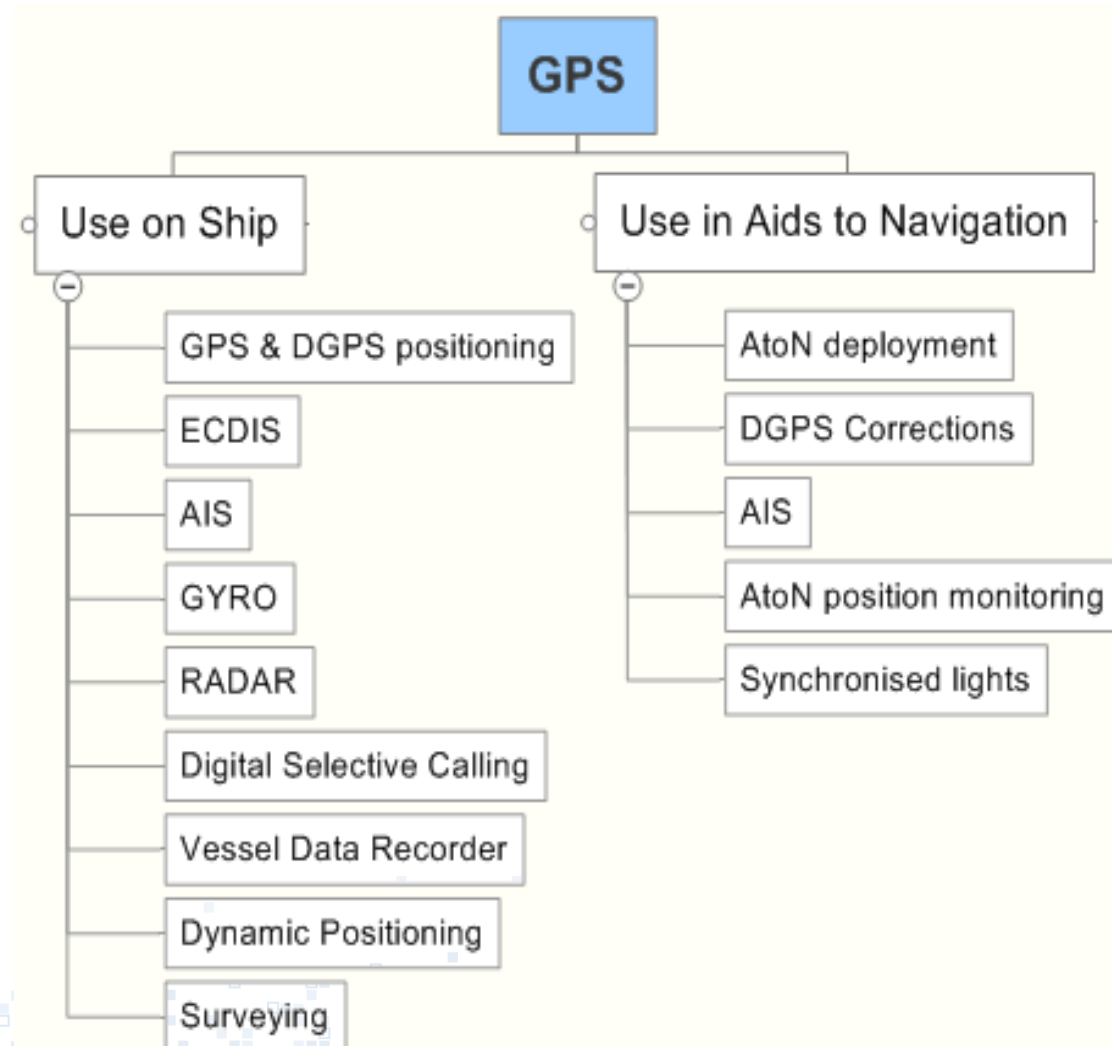
GPS Jamming

- Sold online
  - 'Personal Privacy Device' - PPD
  - $20 and upwards

- 30km range?

GPS + jammer

175,000

Web History | Search settings | Sign in

Google | GPS + jammer | Search Advanced Search

Search: ⦿ the web ○ pages from the UK

Web ➕ Show options...

Results 1 - 10 of about **175,000** for GPS + jammer. (0.16 seconds)

On-Line Shop
www.Direct-Gadget.com   Worldwide Shipping Hot Sales Directly from the manufacture

GPS & GSM Blocker
www.thejammerworld.com/jammer   Professional GPS & GSM Blocker Manufacturer from China.Inquiry Now

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Cell Phone & GPS Blocker
Block GSM, 3G, CDMA, GPS and more.
Use coupon code WINTER for 10% off!
www.xjammers.com

eLoran

- ## Signal in space
  - High Power (200kW – 1MW)
  - Low Frequency (100 kHz)
  - Pulsed

- ## Precise synchronisation, locked to UTC
  - 3x Cs. clocks

- ## Loran Data Channel

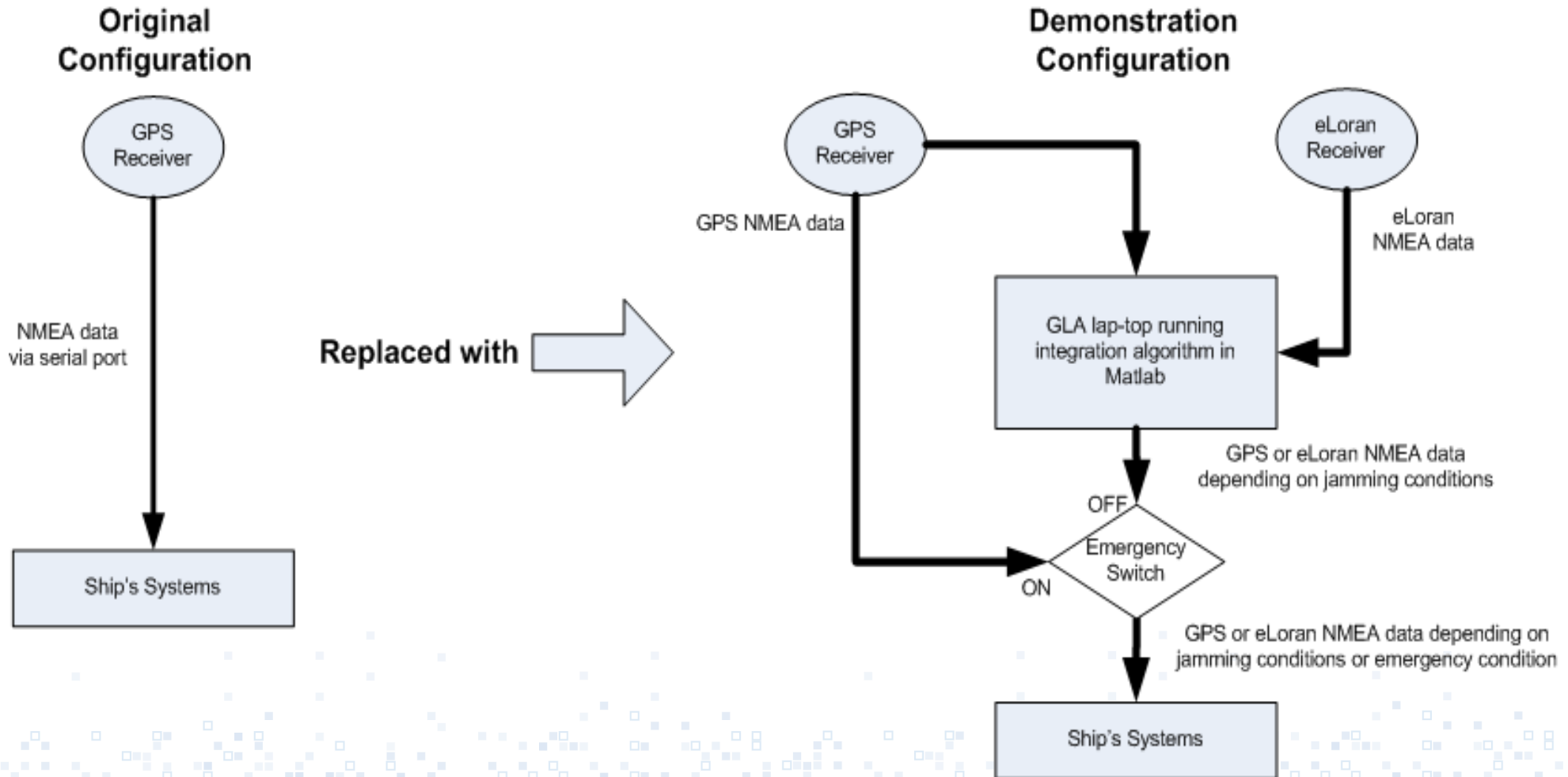- ## Positioning and Timing Backup to GPS

Jamming Trial onboard THV Galatea

- Trinity House Flagship Vessel
  - 5 years old
  - Sophisticated electronic Bridge

- Military (DSTL) Operated Jammer for demonstration
  - Designated Jamming Zone
  - 14 weeks notice

Modifications to THV Galatea

Resilient PNT Data Processor : Implementation

- ▪ **eLoran with GPS Provides Resilient PNT**
  - Complementary
  - Independent
  - Different Failure-Modes

- ▪ **Keep eLoran and GPS Separate**
  - Either / Or switch
  - Keep Independence of eLoran
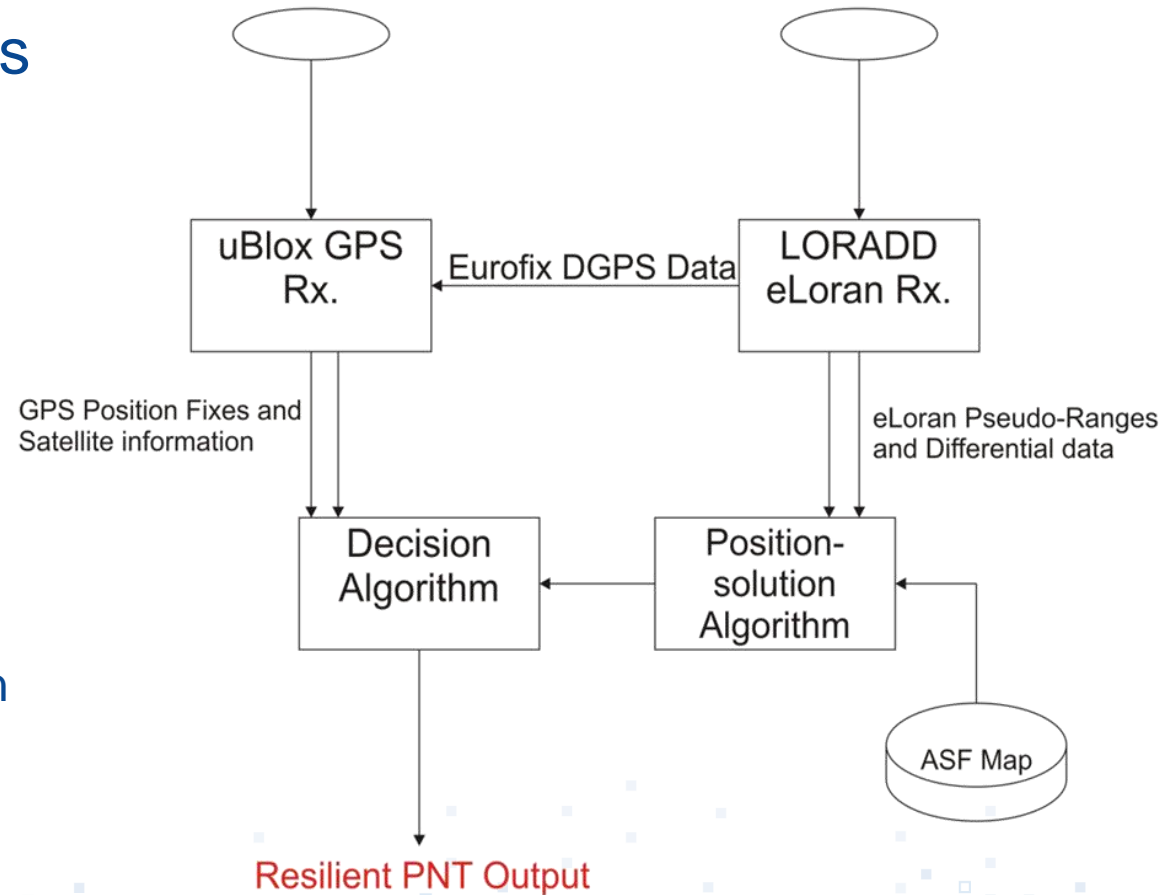
Decision Algorithm

- Input
  - eLoran Data (position fix; HPL; RAIM; Integrity warnings)
  - GPS Data (position fix; HPL; Integrity warnings; Jamming Detection)

- Is GPS OK?
  - Valid fix; HPL<25m; no Warnings; no Jamming?
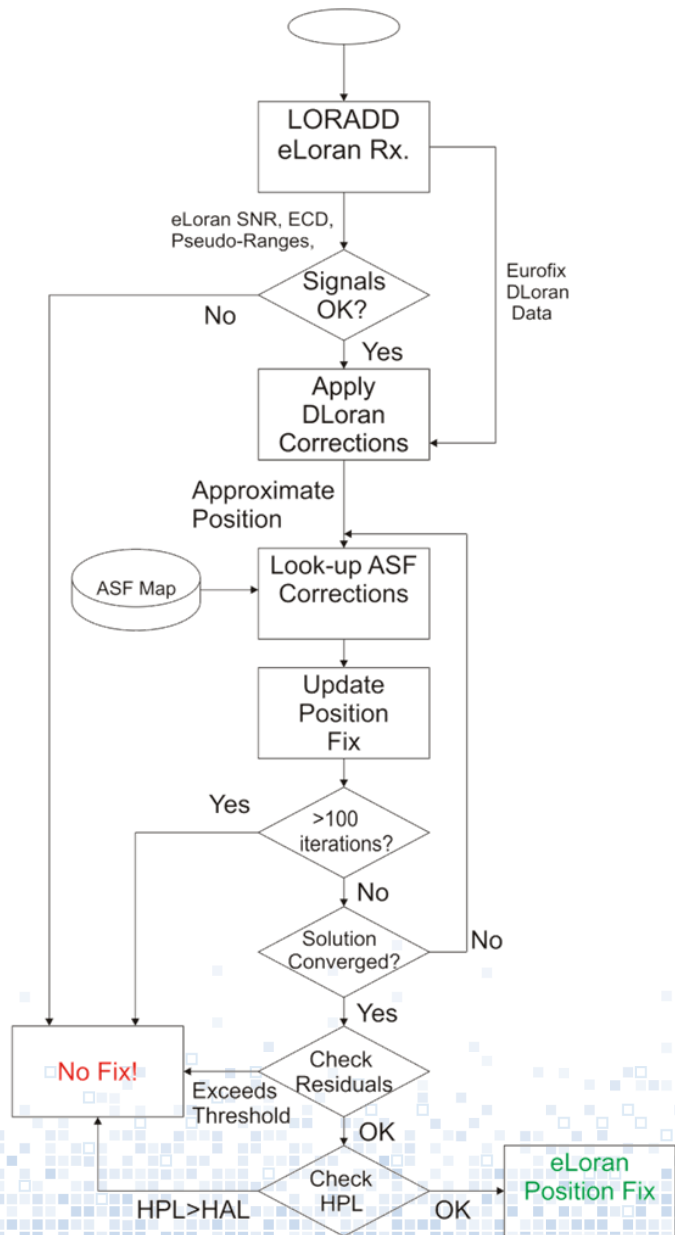 - Use GPS as R-PNT data source

-If not, check is eLoran OK?
  - Valid fix; HPL<25m; check RAIM; no Warnings?
  - Use eLoran as R-PNT data source

- Output
 - Resilient PNT Data (position fix; HPL)

eLoran Integrity

- eLoran Receiver Standards don't include Integrity (yet!)

- Write our own process in software

- Get Integrity-assured eLoran output

Jamming Detection

- **Jamming signal affects Noise Floor**

- **Can see changes in SNR**
  - Model expected SNR
  - Provide 3σ bound
  - Dynamically update model

- **Jamming Detection**
  - SNR outside Bound means SV is jammed
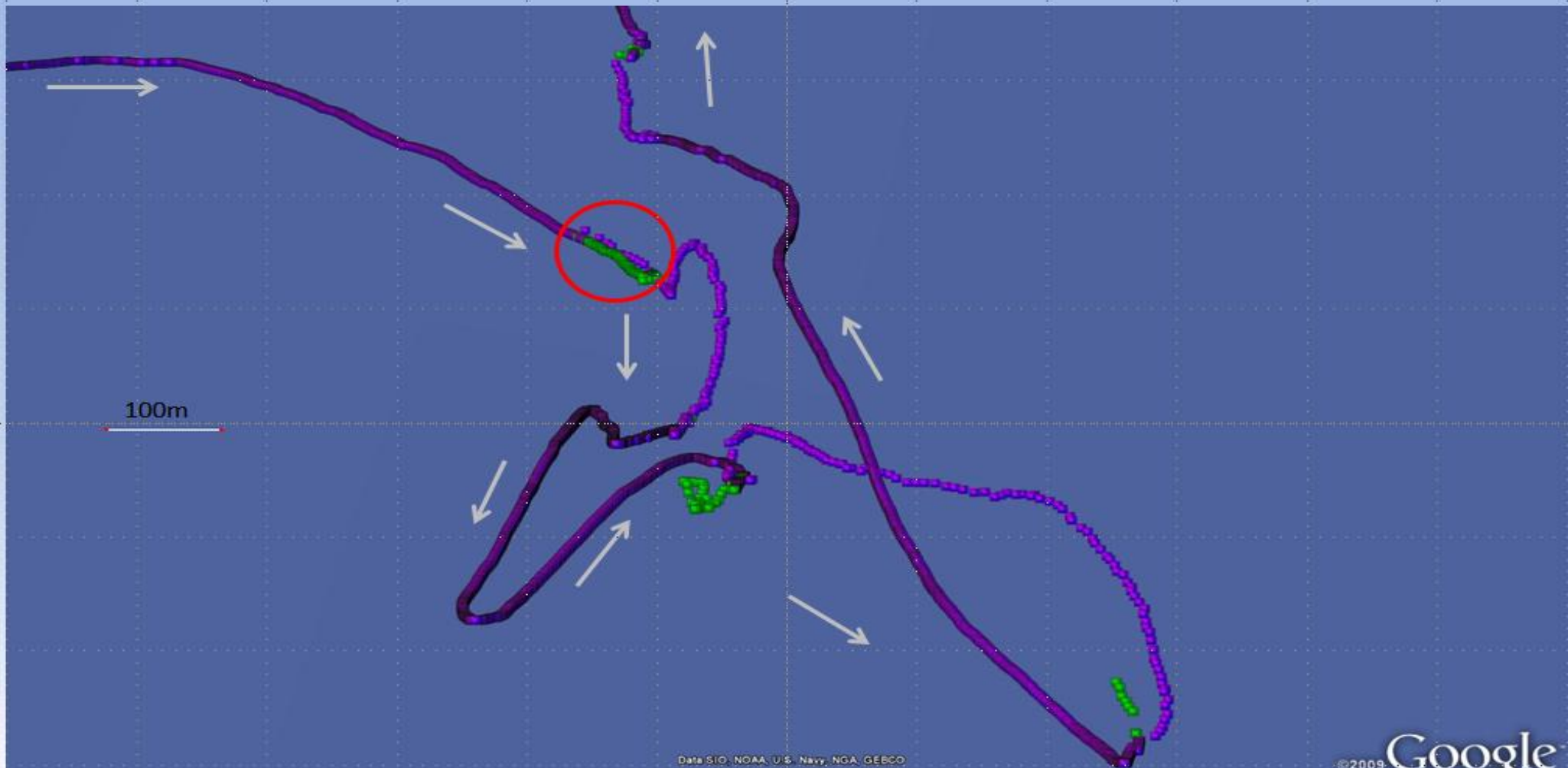 - Problem If several are jammed simultaneously
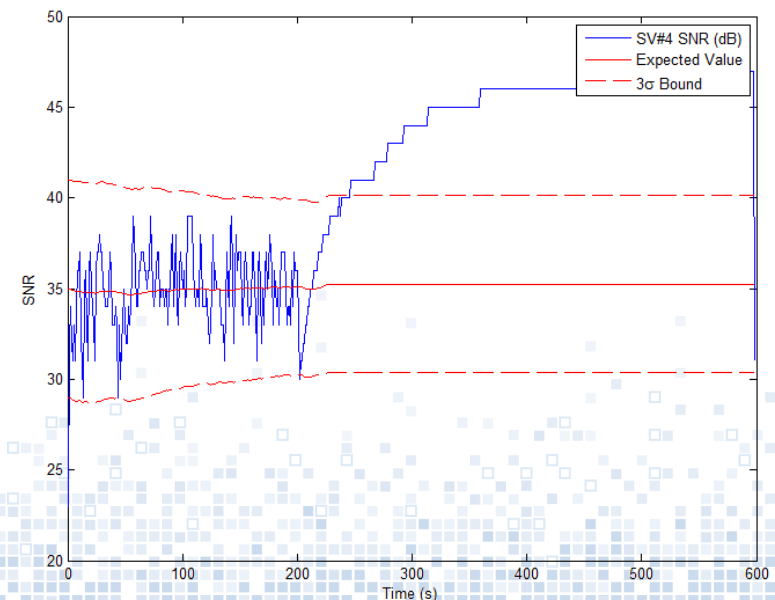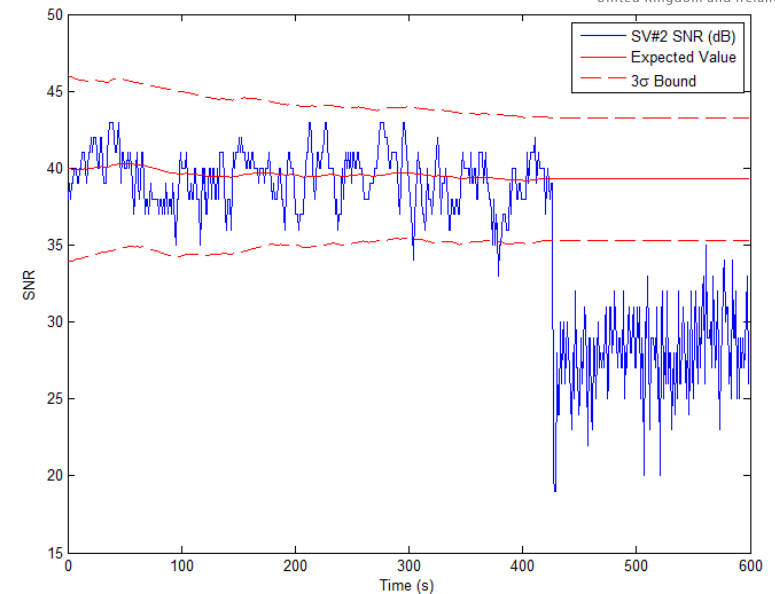
Jamming Outages

Resilient Positioning & Navigation

Resilient Positioning – What you need

- Several, dissimilar sources of PNT
  - GPS (GNSS) as Primary
  - Terrestrial / LF system as Backup
  - Inertial (IMU) / Radar / Signals of Opportunity etc…

- Interference Detection / Integrity
  - Validate **all** incoming PNT information
  - Horizontal Protection Level (HPL) / RAIM
  - GPS Jamming / Spoofing Detection

- Timely, dependable (high fidelity) switching method
  - Reject bad or corrupt data
  - Automatic, seamless transition to secondary / backup system

Summary

- **Resilient PNT by un-coupled GPS + eLoran**
  - Retain Independence
  - Either / Or switch between them

- **Independently verify eLoran and GPS Integrity**
  - Horizontal Protection Level (HPL)
  - Jamming Detection
  - No Standards yet for Maritime GPS / eLoran HPL

- **R-PNT Output based on 'best' system**
  - Provide Resilient Position Data
  - Include HPL

Thank you!

Chris Hargreaves
Research Engineer
General Lighthouse Authorities
Trinity House
The Quay
Harwich
chris.hargreaves@gla-rrnav.org
+44-(0)1255-245154
+44-(0)7825-342979